U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-268 312

Amistad Reservoir
Val Verde County, Texas

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

Feb 77

PB 268 312

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

G.P.O. 699-440

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.	2. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE: Report on Amistad Reservoir, Val Verde County, Texas	5. REPORT DATE: Prepared February 1977
7. AUTHOR(S): Anonymous (National Eutrophication Survey Staff)	6. PERFORMING ORGANIZATION CODE 8. PERFORMING ORGANIZATION REPORT NO.: Working Paper # 631
9. PERFORMING ORGANIZATION NAME AND ADDRESS: National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330	10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS: Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460	13. TYPE OF REPORT AND PERIOD COVERED: Final - 1974 14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES: Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114	

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN-ENDED TERMS	c. COSATI Field/Group
Eutrophication Lakes Nutrients Phosphorus Nitrogen Texas Reservoirs		05B 05C

18. DISTRIBUTION STATEMENT: Release unlimited

19. SECURITY CLASS (This Report): 21. NO. OF PAGES: 58

20. SECURITY CLASS (This Page): 22. PRICE:

01

A04/A02

REPORT

ON

AMISTAD RESERVOIR

VAL VERDE COUNTY

TEXAS

EPA REGION VI

WORKING PAPER No. 651

WITH THE COOPERATION OF THE

WATER QUALITY BOARD

AND THE

TEXAS NATIONAL GUARD

FEBRUARY, 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Texas Water Quality Board for professional involvement, to the Texas National Guard for conducting the tributary sampling phase of the Survey, and to those Texas wastewater treatment plant operators who voluntarily provided effluent samples.

Hugh C. Yantis, Jr., Executive Director of the Texas Water Quality Board, and John B. Latchford, Jr., Director, and the staff of the Field Operations Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Thomas Bishop, the Adjutant General of Texas, and Project Officer Colonel William L. Seals, who directed the volunteer efforts of the Texas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

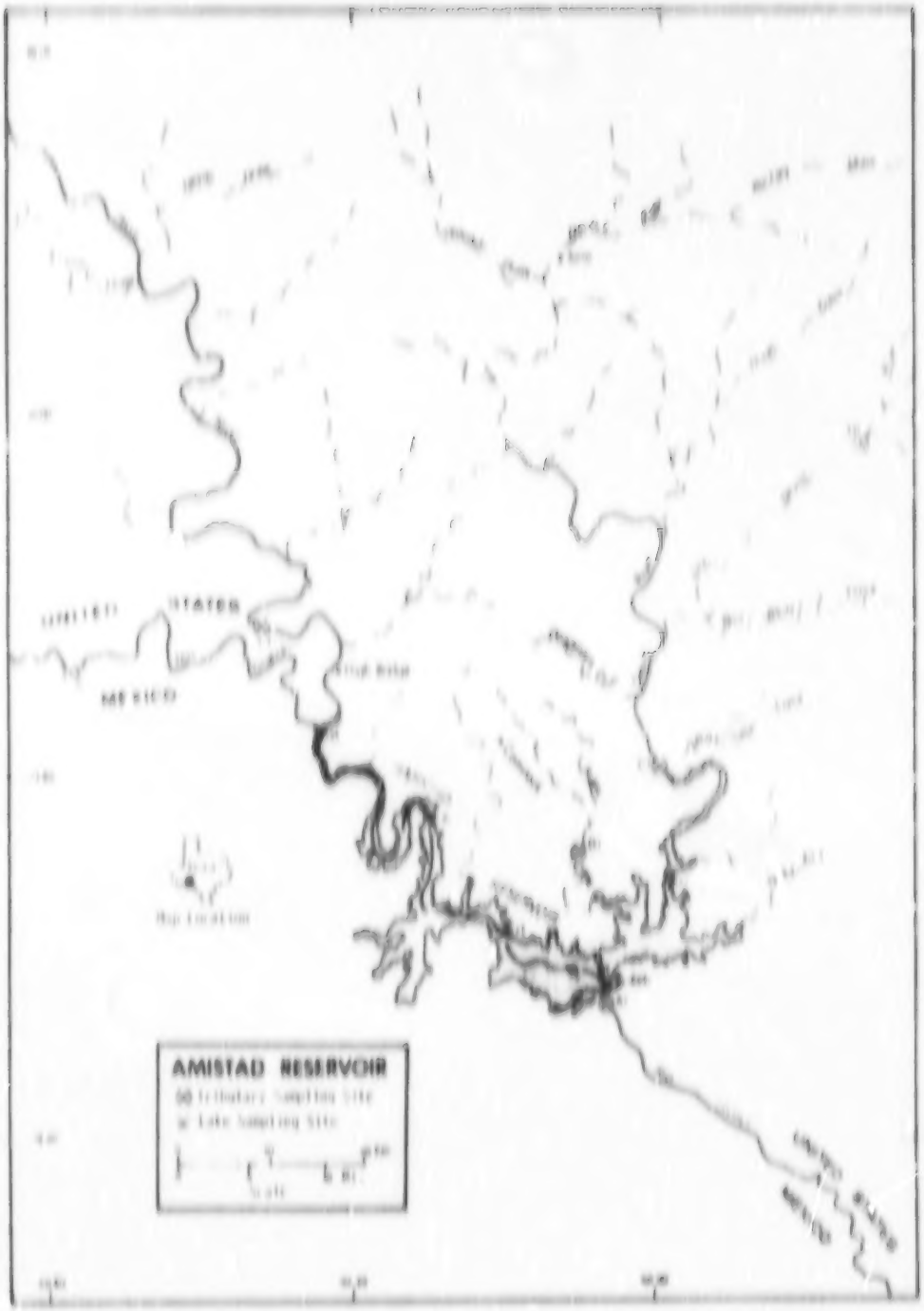
NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of Texas

NAME	COUNTY
Amistad	Val Verde
Bastrop	Bastrop
Belton	Bell, Coryell
Braunig	Bexar
Brownwood	Brown
Buchanan	Burnet, Llano
Caddo	Harrison, Marion, TX; Caddo Parish, LA
Calaveras	Bexar
Canyon	Comal
Colorado City	Mitchell
Corpus Christi	Jim Wells, Live Oak, San Patricio
Diversion	Archer, Baylor
Eagle Mountain	Tarrant, Wise
Fort Phantom Hill	Jones
Houston	Harris
Kemp	Baylor
Lake O'The Pines	Camp, Marion, Morris, Upshur
Lavon	Collin
Lewisville (Garza-Little Elm)	Denton
Livingston	Polk, San Jacinto, Trinity, Walker

Lyndon B. Johnson	Burnet, Llano
Medina	Bandera, Medina
Meredith	Hutchinson, Moore, Potter
O. C. Fisher (San Angelo)	Tom Green
Palestine	Anderson, Cherokee, Henderson, Smith
Possum Kingdom	Palo Pinto, Stephens, Young
Sam Rayburn	Angelina, Jasper Nacogdoches, Sabine, San Augustine
Somerville	Burleson, Lee, Washington
E. V. Spence	Coke
Stamford	Haskell
Stillhouse Hollow	Bell
Tawakoni	Hunt, Rains, Van Zandt
Texoma	Cooke, Grayson TX; Bryan, Johnston, Love, Marshall, OK
Travis	Burnet, Travis
Trinidad	Henderson
Twin Buttes	Tom Green
White River	Crosby
Whitney	Bosque, Hill
Wright Patman (Texarkana)	Bowie, Cass


AMISTAD RESERVOIR

AMISTAD RESERVOIR

STORET NO. 4801

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Amistad Reservoir is mesotrophic; i.e., moderately supplied with nutrients. Whether nutrient enrichment is beneficial or deleterious depends on the actual or potential effect on the uses of the reservoir. In this regard, the Texas Water Quality Board has indicated that there is no known impairment of the designated beneficial uses of Amistad Reservoir.

Amistad ranked fifth in overall trophic quality when the 39 Texas reservoirs sampled in 1974 were compared using a combination of six parameters*. Two of the water bodies had less median total phosphorus, 11 had less and six had the same median dissolved orthophosphorus, 36 had less median inorganic nitrogen, none of the other reservoirs had less mean chlorophyll a, and none had greater mean Secchi disc transparency.

Survey limnologists did not observe any nuisance conditions during their sampling visits. However, marked depression of hypolimnetic dissolved oxygen occurred at stations 1, 2, and 3 in August and October.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Amistad Reservoir was phosphorus limited at the times the samples were collected (03/05-06/74 and 10/29-30/74). The reservoir data indicate phosphorus limitation at all sampling stations and times.

* See Appendix A.

C. Nutrient Controllability:

1. Point sources--No known point sources impacted Amistad Reservoir during the sampling year.

The present phosphorus loading of 0.98 g/m^2/year is over two times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). If Vollenweider's eutrophic loading level is applicable to Texas reservoirs, increasingly undesirable responses to enrichment are likely to occur.

2. Non-point sources--The phosphorus contributions of non-point sources accounted for all of the load during the sampling year. The Rio Grande River contributed 92.3%, Devils River contributed 1.8%, and the Pecos River contributed 1.1%. The ungaged minor tributaries and immediate drainage contributed an estimated 3.0%.

The nutrient export rates of all of the gaged tributaries were quite low (page 12), and it is likely that any significant reduction in non-point phosphorus contributions would be difficult to accomplish.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 262.48 kilometers².
2. Mean depth: 16.5 meters.
3. Maximum depth: 61.0 meters.
4. Volume: 4,330,900 x 10^6 m^3.
5. Mean hydraulic retention time: 3.8 years (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Rio Grande River	209,271.9	38,820
Evans Creek	114.5	0.019
Devil's River	10,259.0	10,900
Pecos River	91,116.1	7,410
Minor tributaries & immediate drainage -	7,804.9	1,357
Totals	318,566.4	58,506

2. Outlet -

Rio Grande River	318,828.9**	35,180**

C. Precipitation***:

1. Year of sampling: 44.7 centimeters.
2. Mean annual: 42.9 centimeters.

† Table of metric conversions--Appendix B.
†† Ito, 1976.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir; lesser outflow due to discharge of springs below the dam and evaporation (Ligner, 1976).
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Amistad Reservoir was sampled four times in 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at five stations on the reservoir in May, August, and October, and four stations in March (see map, page vi). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the March and October visits, two 18.9-liter depth-integrated samples were composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll *a* analysis. The maximum depths sampled were 61.0 meters at station 1, 39.3 meters at station 2, 53.6 meters at station 3, 23.2 meters at station 4, and 42.7 meters at station 5.

The sampling results are presented in full in Appendix D and are summarized in the following table (the August nutrient samples were not properly preserved and were not analyzed).

[illegible]

[illegible]

PARAMETER	RANGE	MEAN	MEDIAN
TEMP (C)	[illegible]	[illegible]	[illegible]
DISS OXY (MG/L)	[illegible]	[illegible]	[illegible]
CNDCTVY (MCHOMO)	[illegible]	[illegible]	[illegible]
PH (STAND UNITS)	[illegible]	[illegible]	[illegible]
TOT ALK (MG/L)	[illegible]	[illegible]	[illegible]
TOT P (MG/L)	[illegible]	[illegible]	[illegible]
DIS P (MG/L)	[illegible]	[illegible]	[illegible]
NO2+NO3 (MG/L)	[illegible]	[illegible]	[illegible]
AMMONIA (MG/L)	[illegible]	[illegible]	[illegible]
KJEL N (MG/L)	[illegible]	[illegible]	[illegible]
ORG N (MG/L)	[illegible]	[illegible]	[illegible]
TOTAL N (MG/L)	[illegible]	[illegible]	[illegible]
CHLOPHYL A (UG/L)	[illegible]	[illegible]	[illegible]
SECCHI (METERS)	[illegible]	[illegible]	[illegible]

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/05/74	1. Cysts	262
	2. Chroomonas sp.	174
	3. Coelastrum sp.	87
	4. Cryptomonas sp.	87
	5. Cyclotella sp.	87
	Other genera	44
	Total	741
06/15/74	1. Coelastrum sp.	161
	2. Cryptomonas sp.	107
	3. Chroomonas sp.	40
	4. Dinobryon sp.	40
	5. Fragilaria sp.	40
	Other genera	68
	Total	456
08/07/74	1. Navicula sp.	730
	2. Chroomonas sp.	370
	3. Oscillatoria sp.	269
	4. Peridinium sp.	168
	5. Centric diatoms	101
	Other genera	268
	Total	1,915
10/29/74	1. Coelastrum sp.	30
	2. Chroomonas sp.	20
	3. Cryptomonas sp.	20
	4. Melosira sp.	20
	5. Scenedesmus sp.	10
	Other genera	21
	Total	121

B

F. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
04/05-06/74	1	0.2
	2	0.2
	3	0.3
	4	1.6
	5	-
05/14-15/74	1	1.2
	2	0.2
	3	1.4
	4	0.7
	5	1.7
08/06-07/74	1	2.7
	2	2.6
	3	2.8
	4	4.3
	5	2.9
10/29-30/74	1	1.1
	2	2.0
	3	3.3
	4	1.8
	5	3.7

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. March sample -

(1). Stations 1 and 2 -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	<0.005	0.299	0.1
0.050 P	<0.055	0.299	5.2
0.050 P + 1.0 N	<0.055	1.299	11.3
1.0 N	<0.055	1.299	0.1

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(2). Stations 3 and 4 -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	<0.005	0.525	0.1
0.050 P	<0.055	0.525	10.8
0.050 P + 1.0 N	<0.055	1.525	11.4
1.0 N	<0.005	1.525	0.1

b. October sample -

(1). Stations 1, 2, and 3 -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.009	0.424	0.3
0.050 P	0.059	0.424	12.5
0.050 P + 1.0 N	0.059	1.424	20.0
1.0 N	0.009	1.424	0.2

(2). Stations 4 and 5 -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.005	(1.058)*	0.2
0.050 P	0.055	(1.058)	13.0
0.050 P + 1.0 N	0.055	(2.058)	16.6
1.0 N	0.006	(2.058)	0.2

2. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that the potential primary productivity of Amistad Reservoir was low in March and moderate in October. The significant increases in yields with the addition of orthophosphorus and the lack of changes in yields when only nitrogen was added indicate phosphorus limitation.

* Sample for nitrogen analysis was inadvertently discarded. The reservoir data indicate a mean inorganic nitrogen concentration of 1.058 mg/l.

The reservoir data also indicate phosphorus limitation; i.e., the mean inorganic nitrogen to orthophosphorus ratios were 14 to 1 or greater in March, May, and October.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Texas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the high runoff month of April when two samples were collected. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Texas District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*.

Because of lack of flow, Evans Creek was not sampled, and the nutrient loads for this stream and the unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads at stations C-1 and E-1, in kg/km^2/year, and multiplying the means by the Evans Creek and ZZ areas in km^2.

No known point sources impacted Amistad Reservoir during the sampling year.

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Rio Grande River	237,445	92.3
Evans Creek	115	0.1
Devil's River	4,585	1.8
Pecos River	2,750	1.1
b. Minor tributaries & immediate drainage (non-point load) -	7,805	3.0
c. Known municipal STP's - None	-	-
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	4,595	1.8
Total	257,295	100.0

2. Outputs -

Lake outlet - Rio Grande River 14,320

3. Net annual P accumulation - 242,975 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Rio Grande River	2,106,250	49.6
Evans Creek	2,515	0.1
Devil's River	930,000	22.1
Pecos River	533,000	12.6
b. Minor tributaries & immediate drainage (non-point load) -	370,640	8.9
c. Known municipal STP's - None	-	-
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	293,375	6.7
Total	4,244,880	100.0

2. Outputs -

Lake outlet - Rio Grande River 1,193,690

3. Net annual N accumulation - 3,051,190 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Rio Grande River	1	10
Devil's River	<1	91
Pecos River	<1	6

* See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.98	0.93	16.2	11.6

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Amistad Reservoir:

"Dangerous" (eutrophic loading)	0.40
"Permissible" (oligotrophic loading)	0.20

V. LITERATURE REVIEWED

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Ligner, James J., 1976. Personal communication (tributary flows). Intn. Boundary & Water Comm., El Paso.

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VI. APPENDICES

APPENDIX A

LAKE RANKINGS

[illegible]

LAKE CODE	LAKE NAME	[illegible] TOTAL #	[illegible] [illegible] %	[illegible] [illegible] SIZE	[illegible] CYCLING	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]
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[illegible] OF LAKES WITH <blank> VALUES [illegible] OF LAKES WITH <blank> VALUES

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] [illegible] P	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

LAKES RANKED BY INDEX VAL.

RANK	LAKE CODE	LAKE NAME	INDEX VAL
29	[illegible]	LYNDON B JOHNSON LAKE	239
30	[illegible]	TEXOMA LAKE	237
31	[illegible]	SOMERVILLE LAKE	236
32	[illegible]	SAN ANGELO RESERVOIR	230
33	[illegible]	TEMPLINE LAKE	176
34	[illegible]	BRUSH LITTLE ELM RESERVO	173
35	[illegible]	TRAVIS	164
36	[illegible]	BRYANS LAKE	159
37	[illegible]	CORPUS CHRISTI LAKE	155
38	[illegible]	HOUSTON LAKE	139
39	[illegible]	LIVINGSTON LAKE	49

LAKES RANKED BY TOTAL SEA

RANK	LAKE CODE	LAKE NAME	INDEX NO.
1	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO.
29	[illegible]	LYNDA & JOHNSON LAKE	239
30	[illegible]	TEXOMA LAKE	217
31	[illegible]	SOMERVILLE LAKE	209
32	[illegible]	SAN ANGELO RESERVOIR	200
33	[illegible]	TEXARKANA LAKE	176
34	[illegible]	ELM/A LITTLE ELM RESERVO	173
35	[illegible]	TRAVIS	169
36	[illegible]	BRYANS LAKE	159
37	[illegible]	CORPUS CHRISTI LAKE	155
38	[illegible]	HOUSTON LAKE	139
39	[illegible]	LIVINGSTON LAKE	91

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

[redacted]

[redacted]

[redacted]

[redacted]	SUB-DRAINAGE AREA (SQ MI)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	25.45	18.34	23.19	28.66	55.59	52.85	33.09	32.29	[redacted]	35.69	19.21	19.43	[redacted]
[redacted]	[redacted]	24.35	24.41	21.64	19.28	24.61	38.36	47.29	54.65	87.56	78.51	28.49	23.33	[redacted]
[redacted]	134.5	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	7.69	6.88	[redacted]	6.65	15.69	12.88	7.33	22.12	17.13	12.63	8.24	7.56	[redacted]
[redacted]	[redacted]	5.18	5.18	[redacted]	6.74	[redacted]	7.46	[redacted]	8.83	13.22	9.94	5.75	5.13	7.41
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

TOTAL DRAINAGE AREA OF LAKE = [redacted]
SUM OF SUB-DRAINAGE AREAS = [redacted]

TOTAL FLOW IN = 788.95
TOTAL FLOW OUT = 437.35

[redacted] FLOWS AND [redacted] FLOWS(CMS)

[redacted]	[redacted]	[redacted]	[redacted] FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
[redacted]	9	74	[redacted]	7	[redacted]				
	10	74	[redacted]	6	[redacted]				
	11	74	[redacted]	7	[redacted]				
	12	74	[redacted]	6	[redacted]				
	1	75	[redacted]	7	[redacted]				
	2	75	[redacted]	6	[redacted]				
	3	75	[redacted]	1	[redacted]				
	4	75	[redacted]	10	[redacted]	23	[redacted]		
	5	75	[redacted]	17	[redacted]				
	6	75	[redacted]	5	[redacted]				
	7	75	[redacted]	24	[redacted]				
	8	75	[redacted]	7	[redacted]				
[redacted]	9	76	[redacted]	7	[redacted]				
	10	76	[redacted]	6	[redacted]				
	11	76	[redacted]	7	[redacted]				
	12	76	[redacted]	6	[redacted]				
	1	77	[redacted]	7	[redacted]				
	2	77	[redacted]	6	[redacted]				
	3	77	[redacted]	1	[redacted]				
	4	77	[redacted]	11	[redacted]	23	[redacted]		
	5	77	[redacted]	17	[redacted]				
	6	77	[redacted]	5	[redacted]				
	7	77	[redacted]	24	[redacted]				
	8	77	[redacted]	7	[redacted]				

[redacted]

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

[illegible]

[illegible]

[illegible]
29 13 38.0 104 44 38.0
[illegible]
[illegible]

[illegible]
[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]
FROM	OF			Δ	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]
[illegible]	14	35	[illegible]	[illegible]	
	14	35	[illegible]	[illegible]	
	14	35	[illegible]	[illegible]	
	14	35	[illegible]	[illegible]	
	14	35	[illegible]	[illegible]	
	14	35	[illegible]	[illegible]	
[illegible]	15	45	[illegible]	[illegible]	
	15	45	[illegible]	[illegible]	
	15	45	[illegible]	[illegible]	
	15	45	[illegible]	[illegible]	
	15	45	[illegible]	[illegible]	
	15	45	[illegible]	[illegible]	
[illegible]	17	45	[illegible]	[illegible]	
	17	45	[illegible]	[illegible]	
	17	45	[illegible]	[illegible]	
[illegible]	13	38	[illegible]	[illegible]	
	13	38	[illegible]	[illegible]	
	13	38	[illegible]	[illegible]	
	13	38	[illegible]	[illegible]	
	13	38	[illegible]	[illegible]	
	13	38	[illegible]	[illegible]	
	13	38	[illegible]	[illegible]	
	13	38	[illegible]	[illegible]	
	13	38	[illegible]	[illegible]	
	13	38	[illegible]	[illegible]	

[illegible]

[illegible]

[illegible]
29 30 58.0 101 35 15.0
[illegible]
[illegible] TEXAS

[illegible]
[illegible]

DATE FROM TO	TIME OF DAY	DEPTH FEET	00045 PRCIP-TOT INCHES	72217 CYLINDER, A INCHES	00231 INCIT LT REMAINS PERCENT
[illegible]	14	58	0.005	0.3	
	14	58	0.010	0.705	
	14	58	0.035	0.005	
	14	58	0.070	0.004	
	14	58	0.130	0.009	
[illegible]	10	55	0.000	0.004	1.0
	10	55	0.005	0.013	
	10	55	0.040	0.009	
	10	55	0.095	0.009	
	10	55	0.130	0.007	
[illegible]	14	58	0.000		2.0
	14	58	0.003			58.0
	14	58	0.042			1.0
[illegible]	15	15	0.000	0.004	3.3	
	15	15	0.001			53.0
	15	15	0.005	0.004		
	15	15	0.020	0.004		
	15	15	0.021			1.0
	15	15	0.040	0.003		
	15	15	0.060	0.007		
	15	15	0.080	0.003		
	15	15	0.09[illegible]	0.009		
	15	15	0.120	0.007		
	15	15	0.135	0.009		
	15	15	0.176	0.006		

[illegible]

[illegible]
29 41 59.8 101 22 29.4
[illegible]
[illegible] 75465

[illegible]
[illegible]

DATE FROM TO	TIME OF DAY	DEPTH FEET	OXYGEN, DISSOLVED MG/L	DENSITY (SIGMA-T) KG/M3	SPECIFIC CONDUCTANCE MICROMHOS PER CENTIMETER
[illegible]	15 45	[illegible]	[illegible]	1.5	
	15 45	[illegible]	[illegible]		
	15 45	[illegible]	[illegible]		
	15 45	[illegible]	[illegible]		
	15 45	[illegible]	[illegible]		
	15 45	[illegible]	[illegible]		
[illegible]	09 40	[illegible]	[illegible]	2.7	
	09 40	[illegible]	[illegible]		
	09 40	[illegible]	[illegible]		
	09 40	[illegible]	[illegible]		
	09 40	[illegible]	[illegible]		
[illegible]	13 10	[illegible]		4.3	
	13 10	[illegible]			58.0
	13 10	[illegible]			1.0
[illegible]	09 05	[illegible]	[illegible]	1.0	
	09 05	[illegible]			58.0
	09 05	[illegible]	[illegible]		
	09 05	[illegible]			1.0
	09 05	[illegible]	[illegible]		
	09 05	[illegible]	[illegible]		
	09 05	[illegible]	[illegible]		
	09 05	[illegible]	[illegible]		

[illegible]

[illegible]

[illegible]

[illegible]
[illegible]
[illegible]

[illegible]
[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]
FROM	OF				
TO	DAY	FEET	[illegible]	[illegible]	[illegible]
[illegible]	10	15	[illegible]	[illegible]	1.7	
	10	15	[illegible]	[illegible]		
	10	15	[illegible]	[illegible]		1.0
	10	15	[illegible]	[illegible]		
	10	15	[illegible]	[illegible]		
[illegible]	14	10	[illegible]		2.9	
	14	10	[illegible]			50.0
	14	10	[illegible]			1.0
[illegible]	00	15	[illegible]	[illegible]	3.7	
	00	15	[illegible]	[illegible]		
	00	15	[illegible]	[illegible]		
	00	15	[illegible]	[illegible]		
	00	15	[illegible]	[illegible]		
	00	15	[illegible]	[illegible]		
	00	15	[illegible]	[illegible]		
	00	15	[illegible]	[illegible]		

[illegible]

APPENDIX E

TRIBUTARY DATA

[illegible]

DATE FROM TO	TIME OF DAY	DEPTH FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
74/10/08	14	30	2.880	0.660	0.040	0.005	0.0170
74/11/07	14	00	0.440	1.300	0.045	0.010	0.015
74/12/06	11	45	0.552	0.500	0.026	0.010	0.022
75/01/07	15	45	0.520	0.500	0.340	0.0054	0.0190
75/02/04	10	15	0.596	0.290	0.020	0.025	0.020
75/03/11	15	00	0.625	0.360	0.025	0.0054	0.0190
75/04/11	11	30	0.630	0.750	0.045	0.005	
75/04/23	11	10	0.650	1.100	0.190	0.0054	0.0190
75/05/17	11	15	0.630	0.280	0.015	0.005	0.0190
75/06/05	13	30	0.620	1.300	0.130	0.0054	0.0190
75/07/09	10	30	0.540	0.400	0.015	0.010	0.010
75/08/07	11	45	0.450	0.525	0.030	0.0054	0.0190

< VALUE GIVEN IS
LESS THAN DETECTION

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	[illegible]	[illegible]	
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible] *	[illegible] *
[illegible]	[illegible]	[illegible]	0.723	0.468	0.596		0.628
[illegible]	[illegible]	[illegible]	2.880	1.488	0.646	0.615	1.350
[illegible]	[illegible]	[illegible]	0.896	0.786	0.828	0.815	0.214
[illegible]	[illegible]	[illegible]	0.768	0.488	0.624	0.884	0.668
[illegible]	[illegible]	[illegible]	2.720	2.488	0.846	0.8854	0.618
[illegible]	[illegible]	[illegible]	0.672	0.288	0.889	0.8894	0.628
[illegible]	[illegible]	[illegible]	0.960	0.658	0.815	0.615	0.2[illegible]
[illegible]	[illegible]	[illegible]	1.888	0.458	0.838	0.838	0.838
[illegible]	[illegible]	[illegible]	0.788	0.388	0.825	0.8854	0.856
[illegible]	[illegible]	[illegible]	0.898	1.648	0.841	0.828	0.618
[illegible]	[illegible]	[illegible]	0.738	1.828	0.828	0.885	0.6184
[illegible]	[illegible]	[illegible]	1.358		0.128	0.725	0.788
[illegible]	[illegible]	[illegible]	0.958	0.458	0.8854	0.835	0.385

* [illegible]
[illegible]

[redacted]

[redacted]

DATE	TIME	DEPTH	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
FROM	OF		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
TO	DAY	FEET	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]